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Introduction

The primary objective of this project is to use scale pattern recognition techniques to determine stock origins of chinook salmon incidentally caught in foreign trawls in the Bering Sea and Gulf of Alaska in 1978, 1979, and 1981. Brood year "standards" constructed from the scale patterns of 1979-1982 inshore samples (known origin) will be used to classify chinook of the same brood year in the trawl samples to region or river of origin. To accomplish this objective, work during the present quarter included: 1) collection of 1982 inshore scale samples, catch, and escapement data; 2) re-ageing of 1979-1982 inshore scale samples; 3) the construction of brood year standards; 4) measurement of freshwater-marine growth patterns on the scales of chinook in both the trawl and inshore samples; and 5) modification of existing FORTRAN programs to re-format the raw scale data and select characters for pattern recognition.

Methods and Results

Collection of 1982 inshore scale samples, catch, and escapement data

Inshore scale samples collected from fisheries resource agencies during the present quarter are shown in Table 1. Collection efforts were concentrated on obtaining 1982 inshore samples from western Alaska, central Alaska, British Columbia, Washington, and Oregon. The samples received during this quarter complete our collection of 1979-1982 North American chinook scales. Just prior to the completion of this report, we received the 1981 Asian scale samples from the Japanese Fishery Agency.

During this quarter, we also completed our collection of 1979-1982 catch and escapement data for all major stocks of North American chinook. These data will be used in conjunction with age composition data to determine the number of scales of each age class and stock to be included in the brood year standards.

Re-ageing of 1979-1982 inshore scale samples

The 1979-1982 inshore scale samples provided by various agencies are being re-aged by Fisheries Research Institute (FRI) scale analysts to 1) establish consistency in age interpretation for all samples to be used in the analysis, and to 2) provide information on the number of usable scales available for our analysis.

The total number of 1979-1982 inshore chinook scale samples examined by FRI scale analysts through March 1983, and the number of fish with readable scales is shown by region or river of origin in Table 2. Readable scales are those for which both a freshwater and an ocean age were recorded by the scale analyst. FRI analysts were instructed to not

age regenerated scales as these are missing one or more circuli and are, therefore, not suitable for scale pattern analyses. Approximately 56,000 scale samples have been examined to date, and of these, approximately 62% are usable for age composition and/or scale pattern analyses. Age compositions of the inshore scale samples will be used to determine the number of scales of each age class and stock to be included in the brood year standards.

A comparison of FRI and Alaska Department of Fish and Game (ADF&G) determinations of the number of scales of each age class, the total number of readable scales, the number of regenerated scales, and the total number of scales for 1979-1982 Nushagak District chinook salmon scale samples is shown in Table 3. Although the scale samples used in this comparison were not always completely identical, the comparison serves to illustrate the effect of rejection of regenerated scales on sample size and age composition. Sometimes as many as half of the scales aged by ADF&G scale analysts were determined by FRI analysts to be regenerated or otherwise unusable for stock separation analyses. However, in spite of considerable differences in the ADF&G and FRI sample sizes, the resulting ADF&G and FRI age compositions of the 1979-1982 Nushagak scale samples, calculated as the unweighted proportions of the total number of readable scales in a sample represented by each age class, were always within 5% agreement of each other (Table 4).

Construction of brood year standards

As we noted in our last report, a complete scale pattern analysis of freshwater age 1. chinook caught in the 1978, 1979, and 1981 trawl fishery will require ten brood year standards for each region or river of origin (Myers & Rogers 1982). During this quarter we completed the construction of most of the brood year standards for five regions (Asia, western Alaska, central Alaska, southeast Alaska/British Columbia, and Oregon/Washington/California), and three "rivers" (Yukon, Kuskokwim, and Bristol Bay [Nushagak and Togiak]). To construct these standards, the total "run size" (catch and/or escapement) for each stock in each year was weighted by the age composition of the respective inshore scale sample to determine a "total return" for each age class in each year. The total return for each age class and stock to be included in a particular brood year standard was then summed to obtain a total "brood year return." Then, the proportion of the total brood year return represented by each age class and stock was computed. This proportion was multiplied by the total sample size of each brood year standard (200 scales) to determine the number of scales needed for each age class and stock. Tables of the run size and age composition data used in these calculations as well as the resulting structure of the brood year standards will be presented in our final report.

Measurement of trawl and inshore scale samples

During this quarter, the measurement of the trawl chinook scale samples was completed. Brood year, National Marine Fisheries Service

(NMFS) statistical area, catch date, age class, and sample size of the trawl samples are shown in Table 5. A total of 3,164 scales were measured. The scales measured include only those from "area-significant" ($N \geq 25$ fish when samples were stratified by NMFS statistical area, month, year, and age class) samples. In addition, only scales designated by observers as having been collected from the preferred (Zone A) or adjacent (Zone B) body areas of the fish were used. The majority of the scales are from two NMFS statistical areas in the eastern Bering Sea (Bering 1 and Bering 2). However, there are also a few samples from two NMFS statistical areas in the western Gulf of Alaska (Shumagin and Chirikof). Some of the Bering Sea samples (particularly the samples collected in 1979) are large enough to be stratified into smaller geographical areas. The Gulf of Alaska samples are all from the fall months (September, October, November), and the Bering Sea samples are from all but the summer months (June, July, August). The Bering Sea samples include four different age classes (1.1, 1.2, 1.3, 1.4) and the Gulf of Alaska samples include two age classes (1.1, 1.2).

Scale characters

During this quarter, existing FORTRAN programs used to reformat the raw scale data and select scale characters for pattern recognition were modified for use in the analysis of the trawl scale samples. The raw scale data collected for each scale consists of the incremental distance to the outer edge of every circulus in each of three zones on the scale. These data will be reduced to the 24 primary characters shown in Table 7. From these 24 primary characters, a total of 60 character combinations (Table 8) will be examined for use in the scale pattern analyses.

References Cited

- Myers, K. W., and D. E. Rogers. 1982. Determination of stock origins of chinook salmon incidentally caught in foreign trawls in the Alaska FCZ. Quarterly Report, October - December 1982, Contract No. 81-5, North Pacific Fisheries Management Council. 8 pp.

Table 1. Inshore chinook salmon scale samples collected from fisheries resource agencies, January - March 1982.

Region	Location	Year	Resource Agency
Western Alaska	Bristol Bay:		
	Nushagak	1982	Alaska Dept. Fish & Game
	Togiak	1982	(Comm. Fish. Div.)
Central Alaska	Cook Inlet:		
	Tyonek Subsist.	1982	"
British Columbia	Yakutat Bay	1982	Canada Dept. Fish & Oceans
	Alsek R.	1982	"
	Chilkat Inlet	1982	"
	Taku R.	1982	"
	Baranof Island	1982	"
	Stikine R.	1982	"
	Behm Canal	1982	"
	Revillagigedo Island	1982	"
	Boca de Quadra	1982	"
	Nass R.	1982	"
	Skeena R.	1982	"
	Kitimat	1982	"
	Bella Coola	1982	"
	Alberni Inlet	1982	"
	Fraser R.	1982	"
Washington	Quileute R.	1982	Quileute Fisheries
	Queets R.	1982	Quinault Indian Nation
	Quinault R.	1982	"
	Humptulips R.	1982	"
	Chehalis R.	1982	"
	Grays Harbor	1982	Washington Dept. Fish.
	Willapa Bay	1982	"
	Hood Canal	1982	"
	Skagit R.	1982	"
	Stillaguamish R. & Snohomish R.	1982	"
	Duwamish R.	1982	"
	Puyallup R.	1982	"
Oregon	Coquille R.	1982	Oregon Dept. Fish & Wildl.
	Tillamook R.	1982	"
	Siuslaw	1982	"
	Yaquina	1982	"
	Coos	1982	"
	Nestucca	1982	"

Table 2. The total number of 1979-1982 inshore chinook scale samples examined by Fisheries Research Institute scale analysts through March 1983, and the number of fish with readable scales by region or river.

Region or river	1979		1980		1981		1982	
	Readable ^a	Total	Readable ^a	Total	Readable ^a	Total	Readable ^a	Total
Western Alaska								
Yukon	879	1,658	794	1,567	794	1,493	1,064	2,313
Kuskokwim	214	449	68	140	1,105	2,569	680	1,958
Bristol Bay	704	1,714	370	834	781	1,915	718	2,054
Central Alaska	579	927	588	1,119	1,368	1,965	2,148	3,896
Southeast Alaska/ British Columbia	1,647	1,967	1,939	2,522	2,728	4,794	2,501	3,866
Washington/Oregon/ California	2,267	3,007	2,531	3,435	3,043	3,919	4,463	5,236
Asia	324	345	362	398				
TOTAL	6,614	10,067	6,652	10,015	9,819	16,655	11,574	19,323

^aReadable scales are those for which both a freshwater and an ocean age were recorded by the scale analyst.

Table 3. Comparison of the number of scales of each age class, the total number of readable scales, the number of regenerated (Regen.) scales, and the total number of scales for 1979-1982 Nushagak District chinook salmon scale samples as determined by Fisheries Research Institute (FRI) and Alaska Department of Fish and Game (ADF&G) scale analysts.

Year	Agency	Age class								Total readable	Regen.	Total ^a
		0.2	0.3	0.4	1.2	1.3	1.4	1.5	Other			
1979	FRI	0	0	0	181	52	176	16	6	431	693	1124
	ADF&G	0	0	0	309	125	299	21	34	788	314	1102
1980	FRI	1	3	5	6	231	75	16	12	349	441	790
	ADF&G	0	0	0	21	408	141	36	0	606	194	800
1981	FRI	0	0	0	163	213	271	4	3	654	951	1605
	ADF&G	0	0	0	282	361	463	8	29	1143	462	1605
1982	FRI	1	0	3	20	235	211	20	11	501	816	1317
	ADF&G	0	0	0	92	443	379	38	78	1030	273	1303

^aTotal number of scales in the ADF&G and FRI samples for the same year may differ somewhat as ADF&G and FRI age determinations were made on different sets of acetate impressions of the same scale samples. The 1979 and 1982 FRI samples both contained one more scale card than the ADF&G samples. Species misidentifications and missing scales were not included in the samples totals.

Table 4. Comparison of age compositions of 1979-1982 Nushagak District chinook salmon scale samples calculated from Fisheries Research Institute (FRI) and Alaska Department of Fish and Game (ADF&G) age determinations.

Year	Agency	Age class						
		0.3	0.4	1.2	1.3	1.4	1.5	Other
1979	FRI	.00	.00	.42	.12	.41	.04	.01
	ADF&G	.00	.00	.39	.16	.38	.03	.04
1980	FRI	.01	.01	.02	.66	.21	.05	.03
	ADF&G	.00	.00	.03	.67	.23	.06	.00
1981	FRI	.00	.00	.25	.33	.41	.01	.00
	ADF&G	.00	.00	.25	.32	.41	.01	.03
1982	FRI	.00	.01	.04	.47	.42	.04	.02
	ADF&G	.00	.00	.09	.43	.37	.04	.07

The age compositions presented in this table are the un-weighted proportion of the total number of readable scales in a sample represented by each age class.

Table 5. Brood year, National Marine Fisheries Service (NMFS) statistical area, catch date, age class, and sample size of trawl-caught chinook salmon scales measured through March 31, 1983.

Brood year	NMFS area*	Catch date		Age** class	Sample size
		Month	Year		
1973	Bering 2	Feb	1979	1.4	39
1974	Bering 2	Nov	1978	1.2	42
	Bering 2	Jan	1979	1.3	51
	Bering 2	Feb	1979	1.3	251
	Bering 2	Mar	1979	1.3	47
	Bering 2	Apr	1979	1.3	55
1975	Bering 1	Sep	1979	1.2	40
	Bering 1	Oct	1979	1.2	104
	Bering 2	Jan	1979	1.2	97
	Bering 2	Feb	1979	1.2	803
	Bering 2	Mar	1979	1.2	81
	Bering 2	Apr	1979	1.2	123
	Bering 2	May	1979	1.2	45
	Bering 2	Nov	1979	1.2	60
	Bering 2	Dec	1979	1.2	43
	Shumagin	Sep	1979	1.2	28
	Bering 2	Jan	1981	1.4	30
1976	Bering 2	Nov	1979	1.1	27
	Bering 1	Feb	1981	1.3	25
	Bering 1	Mar	1981	1.3	29
	Bering 2	Jan	1981	1.3	68
	Bering 2	Feb	1981	1.3	37
	Bering 2	Mar	1981	1.3	29
	Bering 2	Apr	1981	1.3	62
1977	Bering 1	May	1981	1.2	25
	Bering 1	Oct	1981	1.2	40
	Bering 1	Nov	1981	1.2	149
	Bering 2	Jan	1981	1.2	87
	Bering 2	Feb	1981	1.2	47
	Bering 2	Mar	1981	1.2	64
	Bering 2	Apr	1981	1.2	219
	Bering 2	Dec	1981	1.2	53
	Chirikof	Oct	1981	1.2	38
	Chirikof	Nov	1981	1.2	51

Table 5. Brood year, National Marine Fisheries Service (NMFS) statistical area, catch date, age class, and sample size of trawl-caught chinook salmon scales measured through March 31, 1983 - cont'd.

Brood year	NMFS area*	Catch date		Age ** class	Sample size
		Month	Year		
1978	Bering 1	Nov	1981	1.1	43
	Shumagin	Oct	1981	1.1	25
	Chirikof	Oct	1981	1.1	38
	Chirikof	Nov	1981	1.1	69
Total number of scales measured					3,164

*Bering 1 = Bering Sea east of 170°W

Bering 2 = Bering Sea north of 55°N between 180° and 170°W

Shumagin = Gulf of Alaska between 170°W and 159°W within the 200 mile Fishery Conservation Zone.

Chirikof = Gulf of Alaska between 159°W and 154°W within the 200 mile Fishery Conservation Zone.

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The analyses will not include any age 0. chinook salmon.

Table 6. Region or river of origin, brood year, age class, and sample size of 1979-1982 inshore chinook salmon scale samples measured through March 31, 1983.

Region or river	Brood year	Age class(es)	Sample size
Asia	1973	1.3,1.4,1.5	265
	1974	1.2,1.3,1.4	342
	1975	1.2,1.3	90
	1976	1.2	47
Western Alaska			
Yukon	1973	1.5	15
	1974	1.4,1.5	124
	1975	1.3,1.4,1.5	300
	1976	1.2,1.3,1.4	246
	1977	1.2,1.3	272
	1978	1.2	104
Kuskokwim	1973	1.4,1.5	34
	1974	1.3,1.4,1.5	52
	1975	1.2,1.3,1.4,1.5	298
	1976	1.2,1.3,1.4	208
	1977	1.2,1.3	247
	1978	1.2	59
Bristol Bay	1973	1.4,1.5	199
	1974	1.3,1.4,1.5	132
	1975	1.2,1.3,1.4,1.5	364
	1976	1.2,1.3,1.4	213
	1977	1.2,1.3	263
	1978	1.2	37
Central Alaska	1973	1.5	8
	1974	1.4,1.5	70
	1975	1.3,1.4,1.5	191
	1976	1.2,1.3,1.4	213
	1977	1.2,1.3	227
	1978	1.2	37
Southeast Alaska/ British Columbia			
	1974	1.4	87
	1975	1.3	177
	1976	1.2	69
Washington/Oregon/ California			
	1974	1.4	6
	1975	1.3	164
	1976	1.2	108
Total number of scales measured			5,268

Table 7. The twenty-four primary scale characters calculated from raw scale data collected for freshwater age 1. chinook salmon.

No.	Description	Description
1	Radius of nucleus	Distance from center of focus to outer edge of 1st circulus
2	No. circuli in Zone 1	Number of circuli in the first (freshwater) year of growth
3	Size of Zone 1	Distance from center of focus to outer edge of last circulus in the freshwater annulus
4	Distance C ₂ to C ₄ in Zone 1	Distance from the outer edge of the first circulus to the outer edge of every third circulus in the 1st (freshwater) year of growth for up to 5 triplets
5	Distance C ₅ to C ₇ in Zone 1	
6	Distance C ₈ to C ₁₀ in Zone 1	
7	Distance C ₁₁ to C ₁₃ in Zone 1	
8	Distance C ₁₄ to C ₁₆ in Zone 1	
9	No. circuli in Zone 2	Number of freshwater circuli in the second year of growth
10	Size of Zone 2	Distance from the outer edge of the last circulus in the freshwater annulus to the outer edge of the last freshwater circulus
11	No. circuli in Zone 3	Number of ocean circuli in the second year of growth
12	Size of Zone 3	Distance from the outer edge of the last freshwater circulus to the outer edge of the last circulus in the 1st ocean annulus
13	Distance C ₁ to C ₃ in Zones 2+3	Distance from the outer edge of the last circulus in the freshwater annulus to the outer edge of every third circulus in the 2nd year of the growth for up to 12 triplets
14	Distance C ₄ to C ₆ in Zones 2+3	
15	Distance C ₇ to C ₉ in Zones 2+3	
16	Distance C ₁₀ to C ₁₂ in Zones 2+3	
17	Distance C ₁₃ to C ₁₅ in Zones 2+3	
18	Distance C ₁₆ to C ₁₈ in Zones 2+3	
19	Distance C ₁₉ to C ₂₁ in Zones 2+3	
20	Distance C ₂₂ to C ₂₄ in Zones 2+3	
21	Distance C ₂₅ to C ₂₇ in Zones 2+3	
22	Distance C ₂₈ to C ₃₀ in Zones 2+3	
23	Distance C ₃₁ to C ₃₃ in Zones 2+3	
24	Distance C ₃₄ to C ₃₆ in Zones 2+3	

Table 8. Sixty combinations of 24 primary scale characters to be examined for use in the scale pattern analyses of 1978, 1979 and 1981 trawl-caught chinook.

Character No.	Description ^a
1	Size Zone 1
2	Size Zone 2
3	Size Zone 3
4	Size Zone 1 + size Zone 2
5	Size Zone 2 + size Zone 3
6	Size Zone 1 + size Zone 2 + size Zone 3
7	No. circuli Zone 1 + no. circuli Zone 2 + no. circuli Zone 3
8	Size Zone 2/(size Zone 1 + size Zone 2 + size Zone 3)
9	(Size Zone 1 + size Zone 2 + size Zone 3)/(no. circuli Zone 1 + no. circuli Zone 2 + no. Zone 3)
10	(Size Zone 1 + size Zone 2)/(size Zone 1 + size Zone 2 + size Zone 3)
11	(Size Zone 2 + size Zone 3)/(size Zone 1 + size Zone 2 + size Zone 3)
12	No. circuli Zone 1
13	No. circuli Zone 2
14	No. circuli Zone 3
15	No. circuli Zone 1 + no. circuli Zone 2
16	No. circuli Zone 2 + no. circuli Zone 3
17	Size Zone 1/no. circuli Zone 1
18	Size Zone 2/no. circuli Zone 2
19	Size Zone 3/no. circuli Zone 3
20	(Size Zone 1 + size Zone 2)/(no. circuli Zone 1 + no. circuli Zone 2)
21	(Size Zone 2 + size Zone 3)/(no. circuli Zone 2 + no. circuli Zone 3)
22	Distance C1 to C3 in Zones 2+3/(size Zone 1 + size Zone 2 + size Zone 3)
23	Distance C4 to C6 in Zones 2+3/(size Zone 1 + size Zone 2 + size Zone 3)
24	Distance C7 to C9 in Zones 2+3/(size Zone 1 + size Zone 2 + size Zone 3)
25	Distance C10 to C12 in Zones 2+3/(size Zone 1 + size Zone 2 + size Zone 3)
26	Distance C13 to C15 in Zones 2+3/(size Zone 1 + size Zone 2 + size Zone 3)
27	Distance C16 to C18 in Zones 2+3/(size Zone 1 + size Zone 2 + size Zone 3)
28	Distance C19 to C21 in Zones 2+3/(size Zone 1 + size Zone 2 + size Zone 3)
29	Distance C22 to C24 in Zones 2+3/(size Zone 1 + size Zone 2 + size Zone 3)
30	Distance C25 to C27 in Zones 2+3/(size Zone 1 + size Zone 2 + size Zone 3)
31	Distance C28 to C30 in Zones 2+3/(size Zone 1 + size Zone 2 + size Zone 3)
32	Distance C31 to C33 in Zones 2+3/(size Zone 1 + size Zone 2 + size Zone 3)
33	Distance C34 to C36 in Zones 2+3/(size Zone 1 + size Zone 2 + size Zone 3)
34	Distance C1 to C9 in Zone 3
35	Distance C10 to C18 in Zones 2+3
36	Distance C19 to C27 in Zones 2+3
37	Distance C28 to C36 in Zones 2+3
38	Radius of nucleus
39	Distance C2-C4 in Zone 1
40	Distance C5-C7 in Zone 1
41	Distance C8-C10 in Zone 1
42	Distance C11-C13 in Zone 1

Table 8. Sixty combinations of 24 primary scale characters to be examined for use in the scale pattern analyses of 1978, 1979 and 1981 trawl-caught chinook - cont'd.

Character No.	Description ^a
43	Distance C14-C16 in Zone 1
44	Distance C2-C4 in Zone 1/(size Zone 1 + size Zone 2 + size Zone 3)
45	Distance C5-C7 in Zone 1/(size Zone 1 + size Zone 2 + size Zone 3)
46	Distance C8-C10 in Zone 1/(size Zone 1 + size Zone 2 + size Zone 3)
47	Distance C11-C13 in Zone 1/(size Zone 1 + size Zone 2 + size Zone 3)
48	Distance C14-C16 in Zone 1/(size Zone 1 + size Zone 2 + size Zone 3)
49	Distance C1 to C3 in Zones 2+3
50	Distance C4 to C6 in Zones 2+3
51	Distance C7 to C9 in Zones 2+3
52	Distance C10 to C12 in Zones 2+3
53	Distance C13 to C15 in Zones 2+3
54	Distance C16 to C18 in Zones 2+3
55	Distance C19 to C21 in Zones 2+3
56	Distance C22 to C24 in Zones 2+3
57	Distance C25 to C27 in Zones 2+3
58	Distance C28 to C30 in Zones 2+3
59	Distance C31 to C33 in Zones 2+3
60	Distance C34 to C36 in Zones 2+3

- ^aZone 1: The area of the scale from the center of the focus to the outer edge of the last circulus in the freshwater annulus.
- Zone 2: The area of the scale from the outer edge of the last circulus in the freshwater annulus to the outer edge of the last freshwater circulus.
- Zone 3: The area of the scale from the outer edge of the last freshwater circulus to the outer edge of the last circulus in the first ocean annulus.
- C_n: The incremental distance from the outer edge of the previous circulus (C_{n-1}) to the outer edge of circulus n.